AMERICAN MUSEUM NOVITATES

Number 829 Published by THE AMERICAN MUSEUM OF NATURAL HISTORY New York City March 19, 1936

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TWISTED CRYSTALS OF PYRITE AND SMOKY QUARTZ

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Twisted crystals are so rare in nature that any information regarding new occurrences is worthy of record. General accounts of the phenomenon of twisting in crystals have been given by Spencer (1921), Bernauer (1929), and Rossmann (1934).

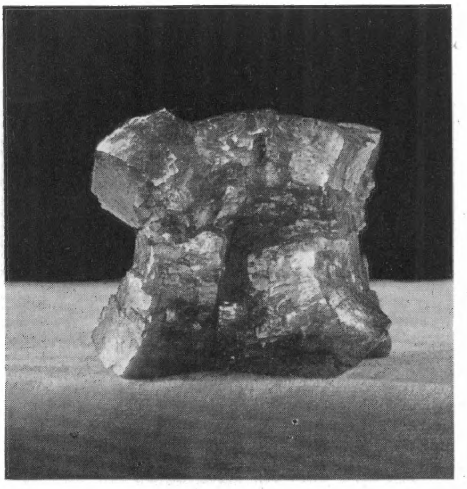


Fig. 1. Pyrite crystal twisted on the trigonal axes of symmetry. Natural size.

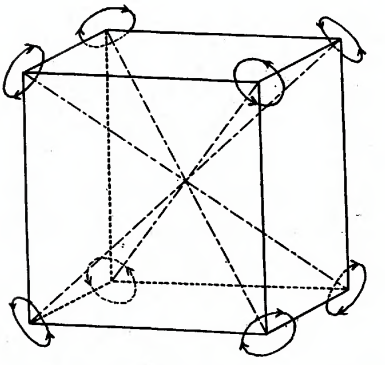


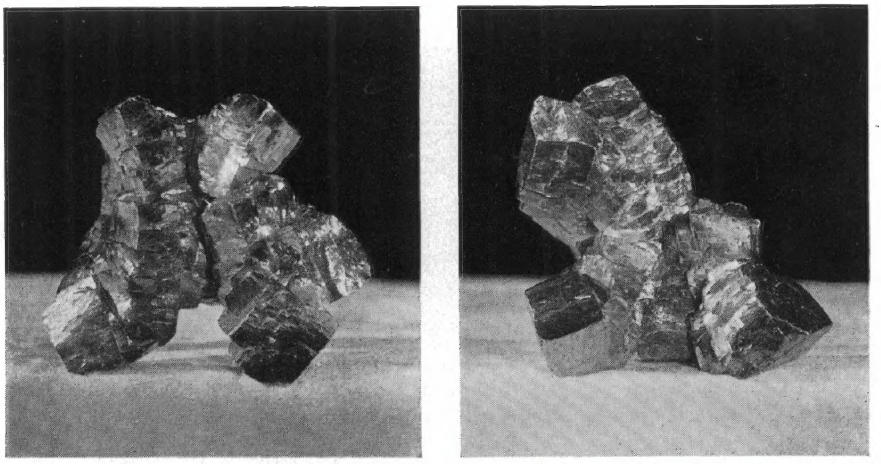
Fig. 2. Diagram illustrating the sense of the twist in the trigonal axes.

PYRITE, FRENCH CREEK, CHESTER COUNTY, PENNSYLVANIA

Axially twisted pyrite crystals have not heretofore been described, although bent crystals and crystals with concave or convex faces are known. The present instance is afforded by a suite of 16 specimens from French Creek, Chester County, Pennsylvania, which exhibit twisted and twisted skeletonized cubes of pyrite implanted on drusy crystals of magnetite and specularite. The pyrite crystals on a few of the specimens are partly covered by deeply etched crystals of calcite that are colored green by included fibers of byssolite.

A typical twisted cube is shown in Fig. 1. The axes of torsion are the trigonal (octahedral) axes of symmetry. The twist in these axes is such that the opposite corners of each trigonal axis are twisted in the same sense, with the two trigonal axes in each vertical diagonal plane of symmetry each twisted in an opposite sense. This relation is sketched in Fig. 2.

An extreme instance of such twisting is shown in Figs. 3*a*–3*b*. This crystal is a skeletonized and markedly composite cube with the corners twisted, in the manner described, through approximately 60°. The larger individuals forming the twisted, composite crystal are composed of



a *b*

Figs. 3*a*–3*b*. Two views of a skeletonized and twisted pyrite cube. The upper right corner of the cube face represented in Fig. 3*b* has been broken off. Natural size.

much smaller crystals closely aggregated in nearly parallel position. The largest of the sub-individuals are those occupying the corner positions.

Several small pyrite crystals in the suite are not twisted, but exhibit a peculiar composite structure in which eight separate cubes are grouped together to form a single large cube. The several parts are not quite parallel, but diverge at small angles and may be separated, in part, by open cracks. One of these crystals, in which the four crystals forming the base of the larger, composite cube are subordinate in size and do not appear in the photograph, is shown in Fig. 4. The composite structure

in these crystals, and in the preceding, twisted crystals, appears to be the result of lineage growth, as described by Buerger (1934).

Cobalt and arsenic were found by Genth (1875) as impurities in the pyrite from French Creek, and the twisting and composite growth of

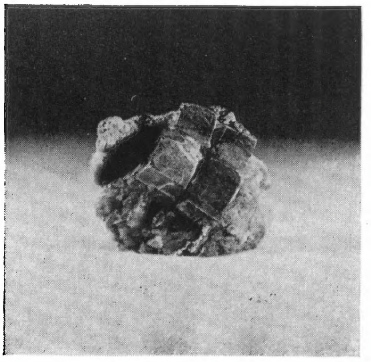


Fig. 4. Composite cube formed of eight separate cubes in approximately parallel position. Only the upper four of the small cubes can be seen in the photograph. Natural size.

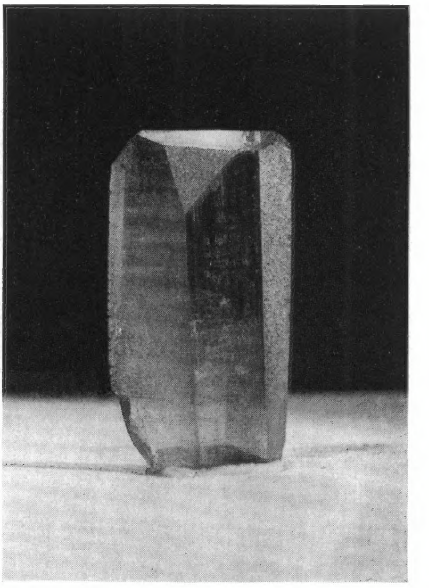


Fig. 5. A pale smoky quartz crystal twisted on a lateral, digonal axis. The crystal is distorted by elongation and flattening parallel to this axis. The horizontal face at the top of the crystal is a prism face—the crystal is oriented with the twisted a-axis vertical—and the small triangular face immediately below it belongs to the trapezohedron $(51\bar{6}1)$. The unusual habit gives the crystal an orthorhombic aspect. St. Gotthard, Switzerland. Natural size.

the crystals is possibly caused by the presence of these elements in solid solution. The dissimilarity of properties—size, polarizability, deformability, etc.—of the foreign atoms and the Fe and S atoms would distort the crystal lattice, and the lattice strain set up in this way would very

likely cause abnormalities in the growth of the crystal. If this is the case, the directional nature of the distortion suggests that the foreign atoms are arranged along certain planes only.

The locality at French Creek has also yielded pyrite crystals that are remarkable in being tetragonal or orthorhombic in outward symmetry, the crystals appearing as curved vicinal pyramids elongated in the direction of one crystallographic axis. These crystals have been described by Penfield (1889), in part from specimens originally contained in the Bement collection and now in the collection of the American Museum.

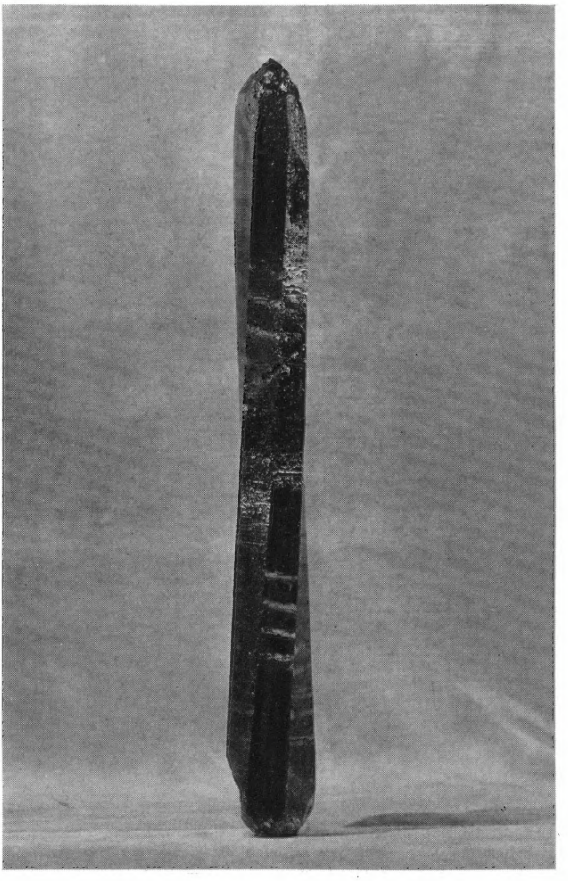


Fig. 6. A dark smoky quartz crystal twisted on the vertical trigonal axis. El Paso County, Colorado. One-half natural size.

SMOKY QUARTZ, EL PASO COUNTY, COLORADO

Twisted smoky quartz crystals from several European localities have been described. Two types of twisting have been found: the axis of torsion being either a lateral, digonal axis, or the vertical, trigonal axis. A crystal of the former type, from St. Gotthard, Switzerland, is shown in Fig. 5. Similar instances from other localities in Switzerland have been described by Tschermak (1894), Rosický (1933), and others.

A smoky quartz crystal twisted on the vertical, trigonal axis, from El Paso County, Colorado, is shown in Fig. 6. The crystal is distorted by flattening parallel to a pair of prism faces and measures 21 × 2.9 × 1.7 cm. It is a right-handed individual, twinned on $(10\bar{1}0)$, with corroded faces of the positive and negative unit rhombohedrons, an unidentified steep rhombohedron, and the right positive trapezohedron $(51\bar{6}1)$. The twist is right-handed and is approximately 45° in 21 cm. of length.

The occurrence of twisting in the smoky variety of quartz and its general absence in the colorless and amethystine varieties suggests a connection with the pigmentation of the crystals, as was found experimentally by Bernauer and others for twisted crystals of various substances grown from solutions containing organic impurities. This would oppose Holden's contention that the pigment of smoky quartz is of a secondary origin, produced in an originally colorless crystal by the action of radiation. The writer (1934) has described further evidence that indicates a primary origin of the color of smoky quartz.

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